Effect of Mechanical Conditioning on In Situ DM and NDF Disappearance of Alfalfa

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Introduction

The physical form of forage may have an effect on rate of digestion. Several studies found severely conditioned macerated forage had greater rates and extents of fiber digestion than conventionally conditioned forages. Koegel et al. (1992) found the average dry matter digestibility of macerated alfalfa silage in sheep was 15.9% greater than conventionally conditioned silage. Hong et al. (1988) determined macerated alfalfa fed as dry hay had a significantly higher extent of neutral detergent fiber (NDF) digestion compared to conventionally treated alfalfa. Suwarno et al. (1997) found that DM digestibility of macerated hay fed to beef steers was 6.6% greater than roller conditioned hay. Mertens and Koegel (1996) found that maceration of alfalfa resulted in greater milk production and a more positive energy balance.

Not all research, however, has reported increased forage utilization as a result of severe conditioning. Conflicting results on the rate and extent of digestibility may have been attributable to different levels of conditioning. It is possible that in those studies where improved digestion and fermentation properties were found, the conditioning level was greater than in those studies where no such differences were found. However, level of conditioning was not measured in any of these studies. Therefore, the objective of this research was to determine the correlation between conditioning level, as measured by the leachate conductivity, and digestibility of DM and NDF of alfalfa (*Medicago sativa*).

Methods

Third crop late vegetative alfalfa at 84% moisture w.b. was harvested at the University of Wisconsin Madison Experimental Station in Madison, WI on August 18, 1994. This alfalfa was conditioned at 4 different levels. Four treatment 1, the alfalfa was not conditioned. For treatment 2, the alfalfa was conditioned with a pair of intermeshing rubber-covered rolls similar to those used in conventional mower-conditioners. For treatment 3, the alfalfa was conditioned using a crushing-impact conditioning mechanism (Kraus et al. 1993). This mechanism severely crushed and shredded the alfalfa stems into long fibrous pieces. For treatment 4, the alfalfa was conditioned using the rotary-impact macerator. This unit had several blunt blades attached to a high speed electric motor which was mounted inside a cylindrical tube. As the alfalfa was metered into the center of the rotating blades, it was impacted numerous times by the blunt blades before it exited the mechanism. This process extremely macerated the alfalfa. After the alfalfa was conditioned, the leachate conductivity of 10 samples from each treatment was measured according to the methods described in Kraus (1997).

Two fistulated Holstein dairy cows having similar milk production and days in lactation were selected for this study. Both cows were fed daily at 8:00 A.M. to obtain *ad libitum* intake. Diets consisted of approximately 72% alfalfa silage, 20% cracked corn, 7% soybean meal, 0.5% dicalcium phosphate, and 0.5% trace mineral salt. The polyester bags were inserted into the rumen of each cow 1 h after feeding.

Typically, in situ digestibility is measured on ground forage samples. Grinding homogenizes the samples and reduces the volume of each sample, allowing many samples to be placed into the rumen simultaneously. Because the effect of conditioning was being examined, the forage samples of this experiment were not ground. Consequently, the volume of each sample was relatively large. To prevent over-filling the rumen, 12 samples, 3 of each treatment, were placed in each rumen 1 h after feeding and all were removed at the same time. The digestion times, 6, 12, 24, and 48 h were carried out over successive days.

At the end of each digestion period, the samples were removed, submerged in ice water to suppress microbial activity, and washed with cool tap water until the washings appeared clean. The washed samples were oven dried at 60°C for 72 h and weighed to determine the final DM contents. After weighing, each polyester bag was opened, and the sample was ground through a 2 mm mesh screen using a small Wiley mill. The neutral detergent fiber (NDF) of each digested sample was measured. The NDF of an undigested oven dried sample was also measured to provide an estimate of the initial NDF concentration of each digested sample.

The kinetics of DM digestion were modeled using a simple first-order kinetic equation with the addition of a discrete instantly soluble fraction (Mertens, 1997). An independent instantly soluble fraction was estimated for each treatment; however, a common digestion rate constant and a common fraction of indigestible residue was estimated for all treatments.

The kinetics of NDF digestion were analyzed using a first-order kinetic equation with the addition of a discrete lag time based on that of Mertens and Lofton (1980). An independent lag time was estimated for each treatment; however, a common digestion rate constant and a single fraction of indigestible residue were estimated for all treatments, and lag times were not allowed to be less than zero.

Results

The degree of conditioning of the four treatments, as measured by leachate conductivity, were as follows:

Treatment	Leachate conductivity (µS/cm)
Control	28
Mower-Conditioner Rolls	60
Crushing-Impact	518
Rotary-Impact	992

Figure 1 is a “best fit” plot of DM disappearance vs. digestion time for each treatment. Figure 2 is a “best fit” plot of NDF disappearance as a fraction of total DM vs. digestion time for each treatment. Compared to the unconditioned material (28 µS/cm), conditioning with intermeshing rubber rolls (60 µS/cm) increased the instantly solubilized DM fraction from 0 to approximately 11%. Similarly, the crushing-impact treatment (518 µS/cm) increased the instantly solubilized DM fraction to nearly 34%.

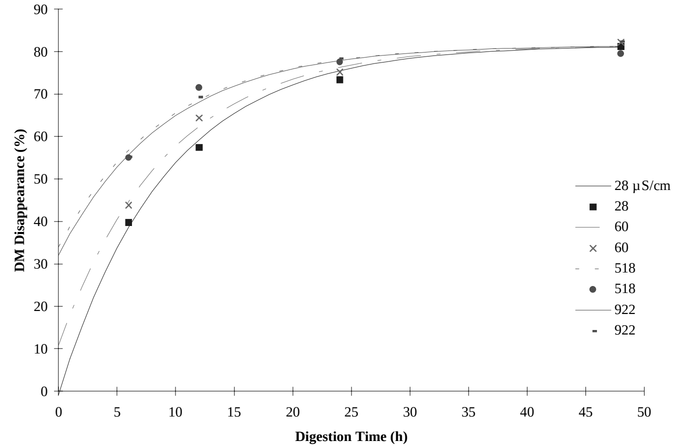

Figure 1. Level of conditioning vs. DM disappearance of alfalfa.

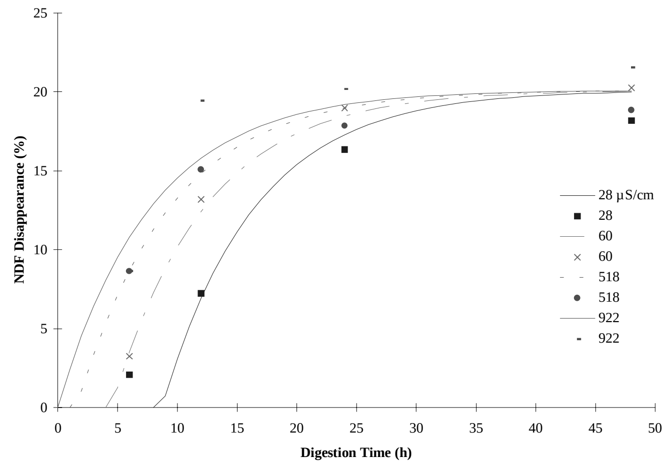

Figure 2. Level of conditioning vs. NDF disappearance of alfalfa.

The DM digestion model suggests that mechanical conditioning increased the instantly soluble DM fraction; however, mechanical conditioning did not increase the DM digestion rate constant. These results suggest that mechanical conditioning of plant tissue ruptured cells which allowed intercellular constituents to be solubilized instantly. Compared to the unconditioned material (28 µS/cm), conditioning with intermeshing rubber rolls (60 µS/cm) reduced the lag time from 8.7 to approximately 4.5 h. The crushing-impact treatment (518 µS/cm) decreased the lag time to approximately 1.5 h. The rotary impact treatment (992 µS/cm) allowed digestion of fiber to begin immediately.

The NDF digestion model suggests that mechanical conditioning decreased the lag time associated with the digestion of fiber but did not change the NDF digestion rate constant. The lag time associated with fiber digestion in the model may reflect the time required for microbes to penetrate cells and begin digestion from the interior surface of plant cell walls. Mechanical conditioning allowed rumen microflora which produce the enzymes for fiber digestion easier access to the inside of the cell wall and thereby allowed them to attach and begin digestion more quickly. This would explain why the lag time decreased as conditioning level increased.

Conclusions

There was a direct correlation between level of conditioning as measured by leachate conductivity and the disappearance of DM and NDF from nylon bags for fermentation times less than 12 h.

A first-order kinetic equation with the addition of a discrete instantly soluble DM fraction indicated that increasing the level of conditioning increased the fraction of DM instantly solubilized in the rumen but hat no effect on the rate of digestion or the indigestible DM fraction.

A first-order kinetic equation with the addition of a discrete lag time used to model NDF disappearance from the nylon bags indicated that increasing the level of conditioning decreased the lag time associated with the digestion of fiber in the rumen but had no effect on the rate of digestion or the magnitude of the indigestible fraction.

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